Interim Results

NEPP Evaluation of Automotive Grade Multilayer Ceramic Capacitors (MLCCs)

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Evaluation of Automotive Grade MLCCs to be presented by Jay Brusse at the NASA Electronic Parts and Packaging (NEPP) Electronics Technology Workshop, Greenbelt, MD, June 17-19, 2014.

Acronyms

AEC	Automotive Electronics Council
ASRC	Artic Slope Regional Corporation
BME	Base Metal Electrode
DF	Dissipation Factor
DPA	Destructive Physical Analysis
DWV	Dielectric Withstanding Voltage
FY	Fiscal Year
IR	Insulation Resistance
MLCC	Multilayer Ceramic Capacitor
NEPP	NASA Electronic Parts & Packaging
PME	Precious Metal Electrode

Outline

- Objectives
- Approach
- Interim Results
- Summary
- Next Steps

Objectives

Do "Off the Shelf" Automotive Grade MLCCs Meet their Initial Qualification Requirements?

- Obtain "Automotive Grade" MLCCs through standard distribution from three major suppliers
  - Parts must be advertised as "AEC Q-200" qualified
- Test "Automotive Grade" MLCCs to selected requirements of AEC Q-200 and associated manufacturer data sheets
  - Destructive Physical Analysis (DPA)
  - Basic electrical parameters (capacitance, DF, DWV, IR)
  - 1000 Hour Life Test (2x rated voltage @ 125°C)
    - To be extended (2k – 4k hours) pending results
- Provide Failure in Time Data to NEPP Researcher (D. Liu) Who Has Previously Tested these same MLCCs via Highly Accelerated Life Stress Testing for Use in Calculating Acceleration Factors and Activation Energies

What is AEC Q-200?

- Automotive Industry Standard for the Qualification of Passive Components
  - AEC Q-200 provides guidelines for Initial Qualification and Re-qualification tests in the event of material, process or design changes
  - AEC Q-200 is NOT a procurement specification
  - AEC Q-200 does NOT specify screening requirements
- Component manufacturers self-qualify
  - There is no centralized “qualifying activity”
  - Each customer is responsible for reviewing qualification results and determining if baseline meets their mission requirements
- Users procure automotive grade parts either as vendor catalog parts or via source control drawings containing user-specific requirements above and beyond AEC Q-200

AEC Q-200
Qualification Test Requirements for MLCCs

AEC-Q200 REV D
June 1, 2010

Automotive Electronics Council
Component Technical Committee

TABLE 2 - TABLE OF METHODS REFERENCED TANTALUM & CERAMIC CAPACITORS

Stress	No.	Reference	Additional Requirements
Pre- and Post-Stress Electrical Test	1	User Spec.	Test is performed at 25±5°C except as specified in the applicable stress reference and the additional requirements in Table 2.
High Temperature Exposure (Storage)	3	MIL-STD-202 Method 108	Unpowered 1000 hours. Measurement at 24±4 hours after test conclusion. The maximum rated temperature should be employed for the dielectric used in the device.
Temperature Cycling	4	JESD22 Method JA-104	1000 Cycles (-55°C to +125°C) Measurement at 24±4 hours after test conclusion. 30min maximum dwell time at each temperature extreme, 1 min. maximum transition time
Destructive Physical Analysis	5	EIA-469	Only applies to SMD Ceramics. Electrical Test not required.
Biased Humidity	7	MIL-STD-202 Method 103	1000 hours 85°C/85% RH. Note: Ceramics only - Specified conditions: Rated Voltage and 1.3 to 1.5 volts. Add 100Kohm resistor. Tantalums - Rated Voltage Only. Measurement at 24±4 hours after test conclusion. For ceramics that have silver content (e.g., PdAg electrodes), the low voltage portion of this test must also be performed.
Operational Life	8	MIL-STD-202 Method 108	Condition D Steady State T_A=125°C. 2/3 rated for Tantalum caps Full rated for Ceramic caps Measurement at 24±4 hours after test conclusion. The maximum rated temperature and voltage for the dielectric employed in the device shall be used.
External Visual	9	MIL-STD-883 Method 2009	Inspect device construction, marking and workmanship. Electrical Test not required
Physical Dimension	10	JESD22 Method JB-100	Verify physical dimensions to the applicable device specification. Note: User(s) and Suppliers spec. Electrical Test not required.
Terminal Strength (Leaded)	11	MIL-STD-202 Method 211	Test leaded device lead integrity only. Conditions: Ceramics: A (454 g), C (227 g), E (1.45 kg-mm). Tantalums: A (2.27 kg), C (227 g), E (1.45 kg-mm).
Resistance to Solvents	12	MIL-STD-202 Method 215	Note: It is applicable to marked and/or coated components. Add Aqueous wash chemical OKEMCLEAN (A 6% concentrated Oakite cleaner) or equivalent. Do not use banned solvents.
Mechanical Shock	13	MIL-STD-202 Method 213	Figure 1 of Method 213 SMD: Condition F LEADED: Condition C

For this NEPP evaluation we chose to perform these specific tests

All MLCC suppliers Perform Life Test @ 2x rated voltage

AEC-Q200 REV D
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TABLE 2 - TABLE OF METHODS REFERENCED TANTALUM & CERAMIC CAPACITORS

Stress	No.	Reference	Additional Requirements
Vibration	14	MIL-STD-202 Method 204	5g's for 20 min., 12 cycles each of 3 orientations Note: Use 8"X5" PCB .031" thick 7 secure points on one long side and 2 secure points at corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10-2000 Hz.
Resistance to Soldering Heat	15	MIL-STD-202 Method 210	No pre-heat of samples. Note: Test condition D for SMD. Test condition B for Leaded. Pre-heat condition of 150°C, 60-120sec is allowed for ceramic components.
ESD	17	AEC-Q200-002 or ISO/DIS 10605	
Solderability	18	J-STD-002	For both Leaded & SMD. Electrical Test not required. Magnification 50 X. Conditions: Leaded: Method A @ 235°C, category 3. SMD: a) Method B, 4 hrs @155°C dry heat @235°C b) Method B @ 215°C category 3. c) Method D category 3 @ 260°C.
Electrical Characterization	19	User Spec.	Parametrically test per lot and sample size requirements, summary to show Min, Max, Mean and Standard deviation at room as well as Min and Max operating temperatures. Parameters C, DF, IR at min / room / max temperatures to be measured at a minimum. SEE PARAMETER TABLE FOR SUGGESTIONS.
Board Flex	21	AEC-Q200-005	Required for MLCCs only. 60 sec minimum holding time.
Terminal Strength (SMD)	22	AEC-Q200-006	
Beam Load Test	23	AEC-Q200-003	Ceramics Only

NOTE: Pre-stress electrical tests also serve as electrical characterization Interval measurements for 1000 hour tests required at 250 and 500 hrs.

NEPP Evaluation Approach

Automotive Grade MLCCs Selected and Evaluation Plan

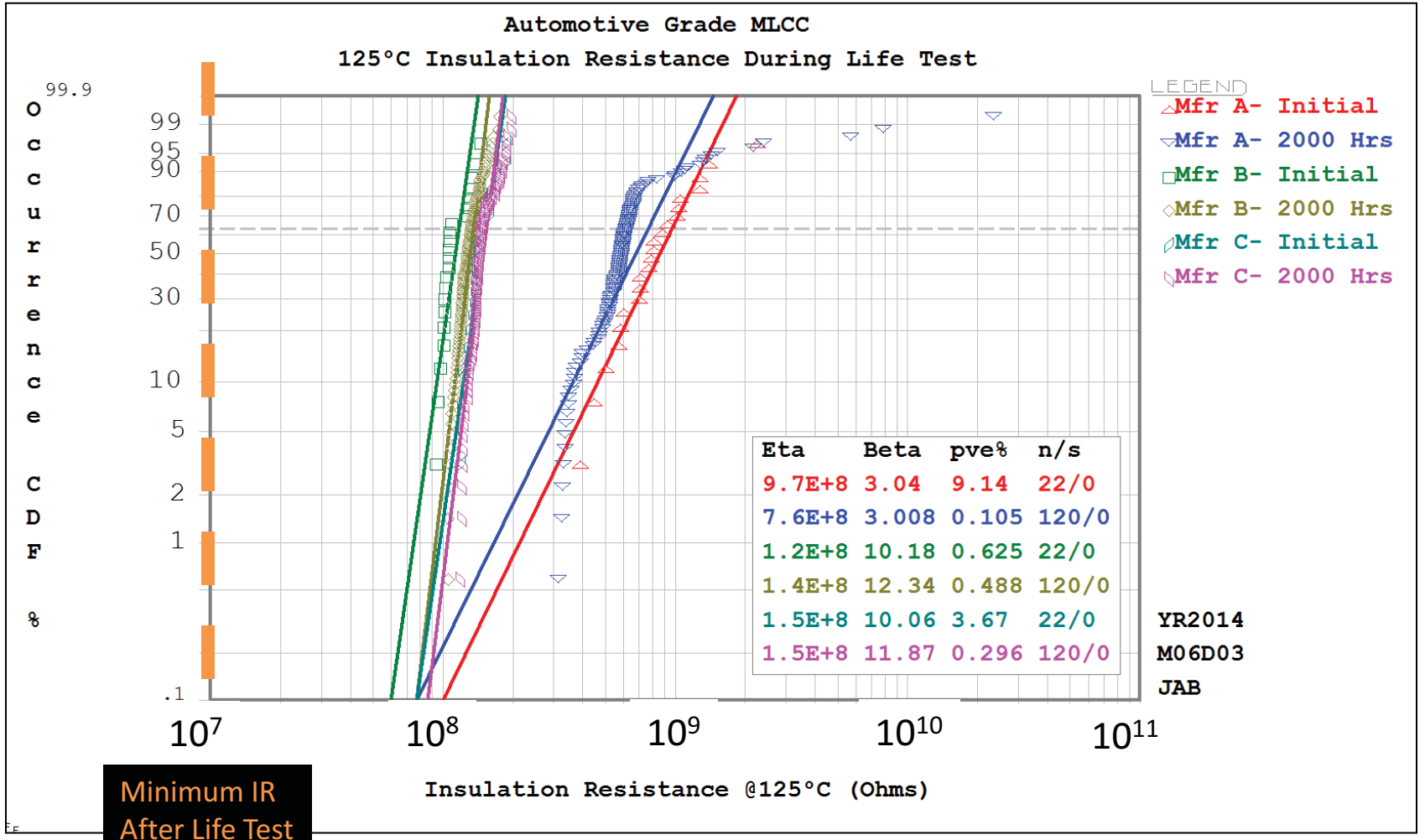
Parts were purchased through distributors as AEC Q-200 advertised catalog parts from Three (3) different suppliers

Mfr	Cap Value (uF)	Voltage Rating (V)	Chip Size	LDC	Dielectric
A	0.47	50	0805	1304	X7R
B	0.47	50	0805	1304	X7R
C	0.47	50	0805	1131	X7R

Test	Status	Comments
Construction Analysis	In Progress	Per EIA 469 5 pcs per lot External Visual + Cross Section with SEM/EDS Determine Materials, Construction, Design
Initial Parametric Measurements Dielectric Withstanding Voltage (DWV) Capacitance (Cap) Dissipation Factor (DF) Room & 125°C Insulation Resistance (IR)	**Complete**	120 pcs per lot **No Failures** **Lesson Learned:** *Expect negative cap shift after DWV test* *Post-DWV bake out is recommended by Manufacturers to restore cap shift induced DWV voltage exposure*
Life Test 2x rated voltage @ 125°C With Interim and final Cap, DF and IR	In Progress	120 pcs per lot **2000 hours complete with No catastrophic failures** Testing is being extended to 4000 hours; Additional life test to be added pending results

Interim Results

Distribution of Insulation Resistance (IR) @ 125°C
0.47uF, 50V, 0805 Automotive Grade BME Capacitors



Minimum IR After Life Test

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Summary

- Life Test through 2000 hours completed; no catastrophic failures;
  - Minimal IR drift observed is within expected behavior

- DWV can cause temporary capacitance suppression (decrease in capacitance)
  - Manufacturers commonly de-age MLCCs after DWV to restore capacitance to nominal values
    - 150°C for 2 - 10 hours followed by 24 hour storage at room temperature prior to reading capacitance

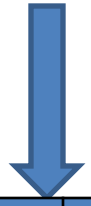
Next Steps

- Continue Life Test
  - Generate Failures at standard life test condition (2x rated voltage @ 125°C)
  - Provide Time to Failure Data to NEPP Researcher who has previously performed Highly Accelerated Life Stress Test on these same capacitor lots
- Complete Construction Analysis/DPA

Next Steps (continued)

FY15 – Planned Additional Automotive Grade Ceramic Capacitors

For FY15
Two additional ceramic chip capacitor ratings
(smaller chip size including lower voltage, higher volumetric efficiency)
advertised as meeting AEC Q-200 are being procured through distributors
from each of three (3) different suppliers for similar evaluation as reported herein



Mfr	Technology	Cap Value	Voltage Rating (V)	Chip Size	Dielectric Class
A	BME	1 nF	50	0402	X7R
B	BME				
D	PME				
A	BME	10 nF	16	0402	X7R
B	BME				
D	PME				

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Questions

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